WHAT WE CLAIM ARE:

1. A method of forming a micro pattern comprising steps of:

(a) coating photosensitive resist material over a substrate and exposing and developing the photosensitive resist material to form a resist pattern; and

(b) etching a surface layer of sidewalls and a top wall of the resist pattern by plasma of a mixture gas of a first gas and an SO_2 gas, the first gas comprising at least one gas selected from the group consisting of He, Ne, Ar, Xe, Kr, CO, CO_2 and N_2.

2. A method of forming a micro pattern according to claim 1, wherein the mixture gas additionally comprises an O_2 gas.

3. A method of forming a micro pattern according to claim 1, wherein in the step (b), a flow rate of the first gas is equal to or larger than 40 % of a flow rate of the mixture gas.

4. A method of forming a micro pattern according to claim 1, wherein in the step (b), the etching is performed in a state that a temperature of the substrate is maintained at 40 °C or lower.

5. A method of forming a micro pattern according to claim 1, wherein:

the substrate has an antireflection film made of organic substance and formed over an underlying surface; and

in the step (b), the surface layer of the resist pattern is etched, and

by using the resist pattern as a mask, the antireflection film is etched.

6. A method of forming a micro pattern according to claim 5, wherein the mixture gas comprises an O_2 gas.

7. A method of forming a micro pattern according to claim 6, wherein the step (b) includes a step of increasing a ratio of a flow rate of the SO_2 gas to a flow rate of the O_2 gas during the etching.

8. A method of forming a micro pattern according to claim 7, wherein in the step (b), the flow rate ratio of the SO_2 gas is increased when the time necessary for etching a whole thickness of the antireflection film lapses.

9. A method of forming a micro pattern according to claim 2, wherein:

the substrate has an antireflection film made of organic substance and formed over an underlying surface; and

in the step (b), the surface layer of the resist pattern is etched, and by using the resist pattern as a mask, the antireflection film is etched.

10. A method of manufacturing a semiconductor device comprising steps of:

(i) forming a first film over a semiconductor substrate;

(j) forming an antireflection film made of organic substance over the first film;

(k) forming a resist film made of photosensitive resist material over the antireflection film;

(l) exposing and developing the resist film to form a resist pattern;

(m) etching a surface layer of sidewalls and a top wall of the resist pattern by plasma of a mixture gas of a first gas and an SO_2 gas, the first gas comprising at least one gas selected from the group consisting of He, Ne, Ar, Xe, Kr, CO, CO_2 and N_2, and by using the resist pattern as a mask, patterning the antireflection film;

(n) etching the first film by using as a mask the resist pattern whose surface layer was etched and the patterned antireflection film; and

(o) removing the resist pattern and the antireflection film.

11. A method of manufacturing a semiconductor device according to claim 10, wherein:

the step (i) comprises a step of forming a second film over the semiconductor substrate and forming the first film over the second film; and

the method further comprises a step of etching the second film by using the first film as a hard mask, after the step (n).

12. A method of manufacturing a semiconductor device according to claim 10, wherein the mixture gas additionally comprises an O_2 gas.

13. A method of manufacturing a semiconductor device according to claim 10, wherein in the step (m), a flow rate of the first gas is equal to or larger than 40 % of a flow rate of the mixture gas.

14. A method of manufacturing a semiconductor device according to claim 10,

wherein in the step (m), the etching is performed in a state that a temperature of the substrate is maintained at 40 °C or lower.

15. A method of manufacturing a semiconductor device according to claim 10, wherein the mixture gas comprises an O_2 gas and the step (m) comprises a step of increasing a ratio of a flow rate of the SO_2 gas to a flow rate of the O_2 gas during the etching.

16. A method of manufacturing a semiconductor device according to claim 15, wherein in the step (m), the flow rate ratio of the SO_2 gas is increased when the time necessary for etching a whole thickness of the antireflection film lapses.

17. A method of forming a micro pattern comprising steps of:

coating photosensitive resist material over a substrate and exposing and developing the photosensitive resist material to form a resist pattern; and

etching a surface layer of sidewalls and a top wall of the resist pattern by plasma of a mixture gas of a first gas and a second gas, the first gas comprising at least one gas selected from the group consisting of He, Ne, Ar, Xe, Kr, CO, CO_2 and N_2, and the second gas forming polymer that comprises sulfur.

18. A method of forming a micro pattern according to claim 17, wherein the mixture gas further comprises an O_2 gas.

19. A method of manufacturing a semiconductor device comprising steps of:

forming a first film over a semiconductor substrate;

forming an antireflection film made of organic substance over the first film;

forming a resist film made of photosensitive resist material over the antireflection film;

exposing and developing the resist film to form a resist pattern;

etching a surface layer of sidewalls and a top wall of the resist pattern by plasma of a mixture gas of a first gas and a second gas, and patterning the antireflection film by using the resist pattern as a mask, the first gas comprising at least one gas selected from the group consisting of He, Ne, Ar, Xe, Kr, CO, CO_2 and N_2, and the second gas forming polymer that comprises sulfur;

etching the first film by using as a mask the resist pattern whose surface layer was etched and the patterned antireflection film; and

removing the resist pattern and the antireflection film.

20. A method of manufacturing a semiconductor device according to claim 19, wherein the mixture gas further comprises an O_2 gas.